



GEOLOGY COMPILED FROM KLEPPER AND OTHERS, 1957 AND KLEPPER, RUPPEL AND OTHERS, 1971,  
BECRAFT AND OTHERS, 1963; SMEDES, 1966; WITH MINOR ADDITIONS  
BY WR. GREENWOOD AND S.D. LUDINGTON, 1977.

SCALE 1:48 000

0 1 2 3 MILES

0 1 2 3 KILOMETERS

CONTOUR INTERVAL 40 FEET

DATUM IS MEAN SEA LEVEL

BASE FROM U.S. GEOLOGICAL SURVEY, 1:62500  
JEFFERSON CITY, TOWNSEND, CLANCY, 1950  
EAST HELENA, CANYON FERRY RESERVOIR

PLATE 1--GEOLOGIC MAP OF THE ELKHORN WILDERNESS STUDY AREA  
JEFFERSON AND BROADWATER COUNTIES, MONTANA

By  
W. R. Greenwood and Steve Ludington  
1978

CONTACT--Approximately located; queried where doubtful  
 --- Contact between shale and overlying carbonate rocks  
 --- FAULT--Dashed where inferred; queried where doubtful  
 --- FOLDS--Showing approximate trace of axial surface and direction of plunge where known  
 + Anticline  
 + Syncline  
 STRIKE AND DIP OF BEDDING  
 -- Inclin  
 -- Vertical  
 ALASKITE-APLITE DIKE OR SILL  
 -- QUARTZ VEIN  
 -- CHALCEDONY VEIN  
 MINES AND PROSPECTS  
 [ ] Shaft (open)  
 [ ] Shaft (caved)  
 X Prospect pit  
 Adit (open)  
 Adit (closed)  
 Prospect trench  
 JOURNALS OF THE ELKHORN WILDERNESS STUDY AREA  
 --- BOUNDARY OF ADDITIONS TO STUDY AREA AS REQUESTED BY U.S.  
 FOREST SERVICE

DESCRIPTION OF MAP UNITS

Q c	TALUS, LARGELY DISSEMINATED, AND COLLUVIUM (QUATERNARY)
Qal	ALLUVIUM, TERRACE AND OTHER GRAVELS, AND HIGH-LEVEL ALLUVIUM (QUATERNARY)
Qs	(QUATERNARY)—locally may include some Tertiary deposits
Qs	GLACIAL MORAINES AND OUTWASH FANS (QUATERNARY)
Qs	SEDIMENT (TERTIARY)—locally may include some Tertiary deposits
Tb	mainly in alluvial fans and lake beds
Tb	BASALT—in part, dense porphyritic basalt containing phenocrysts of labradorite, augite, magnetite(?) and olivine(?) in a groundmass of plagioclase, pyroxene, and opaque minerals. In part, highly vesicular, glassy or finely crystalline lava with conspicuous flow banding. Vesicles are irregular in shape, of variable size, and contain quartz, chlorite, calcite, leucosome(?), and zeolites(?)
Tb	HYPOCISTAL FLANS AND WELOD TUFF—Contains prominent quartz and clear flow layer
Tb	Contains cavities coated with quartz and topaz; includes small amounts of boded air-fall tuff and a few remnants of rhyodacitic tuff along flow
Ts	RYHOLITE PORPHYRY PLUGS AND DIERES—Consists of a stony, light gray, microcrystalline groundmass sustained with bipyramidal quartz phenocrysts
Ts	RYHOLITE REICHA PLUGS AND DIERES—Consists of blocks as large as 1 m across of quartz monzonite, flow-banded rhyolite, and rhyolite porphyry. Includes very fine-grained groundmass of plagioclase, hornblende, biotite, magnetite, and alkali feldspar
Ts	QUARTZ LATITE—Commonly contains abundant, large phenocrysts of quartz and quartzite and some smaller phenocrysts of alkali feldspar, biotite, and hornblende set in a light gray microcrystalline groundmass consisting largely of quartz and alkali feldspar; occurs as several large and numerous ENE-trending dikes
Ts	LAMPHROPHYRE AND RELATED DIERES—Generally dark gray, granitic and porphyritic. Includes quartzite, alkali feldspar, augite lamprophyre, calcite trachysphal porphyry, augite xenodiorite, and allanite-bearing biotite-hornblende trachysphal porphyry
Ts	BOULDER BATOLITH
Ts	Alaskite, apatite, and related rocks—light colored rocks, consisting of potash feldspar (20–30 percent), quartz (35–40 percent), plagioclase (20–30 percent), and biotite (about 10 percent); texture ranges from aplitic through coarse equigranular to pegmatitic. Sheet-like and steeply dipping and irregular bodies, and in some cases, as dikes and batholiths. Accessory minerals include tourmaline and locally monazite, epidote, pyrite, magnetite, and sphene

These irregular beds generally confined to the  
Fowler batholith. Accessory minerals include tourmaline  
and locally polydentite, epidote, pyrite, magnetite, and  
sphene

(Dashed contact shown)

Jefferson Dolomite--Dark-gray granular-weathering field  
well-bedded dolomite with subordinate amounts of dark-gray  
limestone and light-gray dolomite; formation about 222 meters  
thick  
Maywood and Red Lion Formations undivided--Varicolored,  
generally red and yellowish brown, argillaceous, dolomitic,  
and calcareous rocks; poorly exposed. These units are about  
40 meters thick

(Dashed contact shown)

Pilgrim Dolomite--Upper part; Light-gray thick-bedded dolomite  
commonly mottled medium gray near base. Middle part: light- to  
medium-gray near base. Middle part: light- to medium-gray  
limestone irregularly ribbed with yellowish-gray silty  
dolomite. Lower part; mottled light- and dark-gray dolomite  
and limestone. Formation about 152 meters thick

Clark Shale--Olive-gray, gray, and light-brown shale with a  
few thin beds of argillaceous limestone, siltstone, and  
sandstone; poorly exposed; formation about 61 meters thick

(Dashed contact shown)

Meagher Limestone--Upper and lower parts are medium-gray  
limestone irregularly ribbed or mottled with yellowish-orange  
yellowish-brown, and yellowish-gray dolomite; middle unit is  
thickly and indistinctly bedded medium-gray limestone,  
commonly with oolitic beds; formation about 169 meters thick  
Walley Limestone--Upper half is interbedded gray argillaceous  
limestone and greenish- and yellowish-gray calcareous  
sandstone and siltstone; lower half is greenish gray and drab shale  
with some interbeds of sandstone and limestone; may beds are  
micaceous, some are glauconitic; formation about 113 meters  
thick  
Flathead Quartzite--White to pale gray, pink, brown, and  
purple medium- to thick-bedded homogeneous even-grained  
quartz sandstone; most beds are silica cemented forming  
vitreous quartzite; thin discontinuous sparse pebbles zones in  
lower part; crossbedding common; formation about 30 meters  
thick  
BELT SUPERGROUP

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FOURTH SHALE--Dark gray hornstone beds; some reddish and  
purplish beds in lower part; upper part may be Empire Shale;  
formation as much as 520 meters thick

U.S. Geological Survey  
OPEN FILE REPORT

QUADRANGLE LOCATION

MONTANA

U.S. Geological Survey  
OPEN FILE REPORT

This map is preliminary and has not  
been edited or reviewed for conformit-  
with Geological Survey standards or  
nomenclature.

**Hgl** Leucophaeoidite—Light-gray, fine-grained rock between Jackson and Crystal Creek containing about 4 percent biotite, about 48 percent anorthite andesine, 2 percent orthoclase, and about 27 percent quartz

**Xbgn** Quartz monzonite—Quartz monzonite and granodiorite of many textural varieties; mainly, light-gray to medium-gray coarse-grained equigranular and porphyritic quartz(?) monzonite. Mafic minerals include hornblende, plagioclase pyroxene ranges from 4 to 20 percent; plagioclase (andesine to oligoclase) ranges from 72 to 45 percent; potassium feldspar ranges from 15 to 25 percent; biotite ranges from 15 to 35 percent. Accessory minerals include magnetite, ilmenite, apatite, zircon, sphene, and locally or minor epidote, cordierite, clinochlore, titanite, tourmaline, calcite, leuconite, rutile, xenotime, and monazite.

**Xgn** PLUTONS SATURATED TO BOUTLER BATHOLITH

Quartz monzonite—Quartz monzonite to medium-gray commonly medium-grained porphyritic quartz monzonite and granite on the east flank of the Elkhorn Mountains; includes dark, black stocks of fine-grained porphyritic quartz monzonite in the east-central and east flank of the Elkhorn Mountains. Mafic minerals include sparse biotite, hornblende, and secondary chlorite; plagioclase ranges from labradorite to oligoclase; accessory minerals include apatite, zircon, sphene, zircon, and possible aluminite.

**Xgd** Granulite and related rocks—Medium gray to greenish gray, fine- to medium-grained, hornblende, quartz monzonite, granodiorite, syenodiorite, monzonite, and calcic quartz monzonite on the east flank of the Elkhorn Mountains. Mafic minerals (hornblende, plagioclase, and pyroxene) range from 25 to 35 percent; plagioclase (ytroxite to oligoclase) ranges from 40 to 60 percent; potassium feldspar ranges from 15 to 35 percent; quartz monzonite and granodiorite. Accessory minerals include apatite, sphene, magnetite, and small amounts of hematite, ilmenite, and zircon.

**Xm** MAFIC DIOKES—Dark gray to black coarse-grained, equigranular and porphyritic calcic syenodiorite, calcic monzonite, and local amounts of mafic syenite and gabbro on the east flank of the Elkhorn Mountains. Mafic minerals include hornblende, hypersthene, hornblende, and biotite) range from 30 to 35 percent; plagioclase (labradorite to andesine) ranges from 25 to 35 percent; quartz monzonite and granodiorite. Accessory minerals include apatite, sphene, zircon, and magnetite.

**Xt** DIOKES OF ROCKS RELATED TO ELKHORN MOUNTAINS VOLCANICS—Rhyodacite and trachyandesite in dikes, sills, and in small irregular bodies, grading to syenodiorite, granodiorite, and diorite porphyry in larger bodies and concordance bodies.

**Elkhorn Mountains Volcanics**

**Xeu** UPPER MEMBER—Thin to medium-bedded mudstone, andesitic and basaltic siltstone, sandstone, conglomerate and well-sorted bedded tuff; rare andesite flows. About 630 meters thick.

**MIDDLE MEMBER**—About 1,000 to 2,300 meters thick.

**Xem** Undivided—Andesitic and basaltic siltstone, andesitic pyroclastic rocks, mudflow, breccia, conglomerate and a few andesite flows; includes abundant welded tuffs in the southwest of the area.

**Xema** Rhyolitic ash flow tuff—Consists of fragments of pumice and rock fragments in a matrix of largely devitrified glass shards; also contains phenocrysts of feldspar, quartz, hornblende, amphibole, pyroxene, biotite, and ilmenite. The flow ranges from non-welded to densely welded and flow laminated.

**Xel** UNDIVIDED—About 160 to 1,530 meters thick.

**LOWER MEMBER**—About 160 to 1,530 meters thick.

**Xes** Undivided—Andesitic and basaltic siltstone and flow breccia, andesitic rhyolitic and basaltic pyroclastic and andesitic rocks, and mudflow breccia.

**Xslm** Marble—Undivided bedded units of upper unit near Elkhorn Peak.

**SILIM SAND FORMATION**—Comprised of an upper unit of greenish-gray to thick-bedded tuff and sedimentary tuff, and a lower unit of thin-bedded tuff and sedimentary tuff. Interbeds of dark shale. As much as about 370 meters thick.

**NEOSIDIC SEDIMENTARY ROCKS**

**Xol** Colored sandstone—Comprised of an upper unit of black shale with thin sandstone and siltstone beds, a middle unit of quartz-cement sandstone and siliceous mudstone, and a lower unit of dark gray to black sandstone underlain by black shale; formation 305 to 490 meters thick.

**Eosoten Formation**—Comprised of an upper unit of drab mudstone underlain by a thin bed of blue-bearing limestone, a middle unit of red and green mudstone and sandstone with limestone lenses and concretions, and a lower unit of cross-bedded "sand and pebbly" sandstone, shale and mudstone; grades downward into Morrison Formation. Formation about 150 meters thick.

**Morrison Formation**—Varicolored conglomerate shale, mudstone, and siltstone, with thin beds of limestone and sandstone; upper 15 to 25 meters locally contains thick lenticular beds of pebbled-bedded quartz sandstone; formation about 150 meters thick.

**Swift Formation**—Grayish-brown pumy calcareous marine sandstone, with a basal chert pebble conglomerate; formation 6 to 9 meters thick.

**DISCONFORMITY**

**PALEOZOIC ROCKS**—includes:  
Phosphoria Formation and related strata—Brown and gray chert and sandstone, in phosphatic; locally contains one or two thin beds of phosphate rock; formation about 15 meters thick.

**Quadrant Formation**—Light colored quartzitic sandstone and interbedded light-gray sugary-textured, sandy dolomite; formation about 165 meters thick.

**Amesden Formation and Big Snowy Group** undivided—Red to grayish-red siltstone, mudstone, and shale with subordinate calcareous rock and thin beds of locally siliceous sandstone in upper and lower part; generally poorly exposed; middle part is medium- to dark-gray limestone and dolomite; upper part is Amesden limestone, middle and lower parts are Big Snowy Group; these units about 76 meters thick.

**DISCONFORMITY (Dashed contact shown)**

**Bission Canyon Limestone**—Medium- to light-gray thickly and indistinctly bedded limestone, with sparse gray chert nodules and lentils in lower part; contains siliceous layers in lower 200 feet; collapse breccia common in upper part. Grades into local chert in upper 45 to 46 meters zone; formation about 305 meters thick.

**Lodopolea Limestone**—Upper part: medium-gray limestone in distinct beds as much as 10 meters thick alternating with zones of much thinner beds containing sparse mudstone partings; middle part: medium-gray limestone in beds 2 cm to 30 cm thick with partings and lenses of red to red calcareous mudstone. Formation about 215 meters thick.

**Two Forks Shale**—Predominantly greenish-gray and brown shale with subordinate amounts of interbedded sandstone and limestone; dolomitic siltstone at top. Formation about 53 meters thick.

**(Dashed contact shown)**

**Jefferson Dolomite**—Dark-gray granular-weathering feebly well-bedded dolomite with subordinate amounts of dark-gray limestone and light-gray dolomite; formation about 222 meters thick.

**Waywood and Red Lion Formations** undivided—Varicolored, generally red and yellowish brown, argillaceous, dolomitic, and calcareous rocks; poorly exposed. These units are about 40 meters thick.

**(Dashed contact shown)**

**Pilgrim Dolomite**—Upper part: light-gray thick-bedded dolomite commonly mottled medium gray near base. Middle part: light-medium-gray near base. Middle part: light- to medium-gray limestone irregularly banded with interbedded argillaceous dolomite. Lower part: mottled light- and dark-gray dolomite and limestone. Formation about 152 meters thick.

**Park Shale**—Olive-gray, gray, and light-brown shale with a few thin beds of argillaceous limestone, siltstone, and sandstone; poorly exposed; formation about 61 meters thick.

**(Dashed contact shown)**

**Mesher Limestone**—Upper and lower parts are medium-gray limestone irregularly ribbed or mottled with yellowish-orange thickly and indistinctly bedded medium-gray dolomite; middle unit is commonly with oolitic light-colored medium-gray limestone.

**Wells Limestone**—Upper half is interbedded gray argillaceous mudstone and shale; lower half is yellowish-gray calcareous mudstone and shale. Formation about 169 meters thick.

**Wells Limestone and Gray Shale**—Medium- and dark shale mudstone, some are glauconitic; formation about 113 meters thick.

**Flathead Quartzite**—White to pale gray, pink, brown, and purple medium- to thick-bedded homogeneous even-grained quartz sandstone; most beds are siliceous cemented forming quartzitic; thin discontinuous sparse pebbles zones in thin bedded; crossbedding common; formation about 30 meters thick.

**NEW SUBGROUP**

**SQUAWAN SHALE**—Dark